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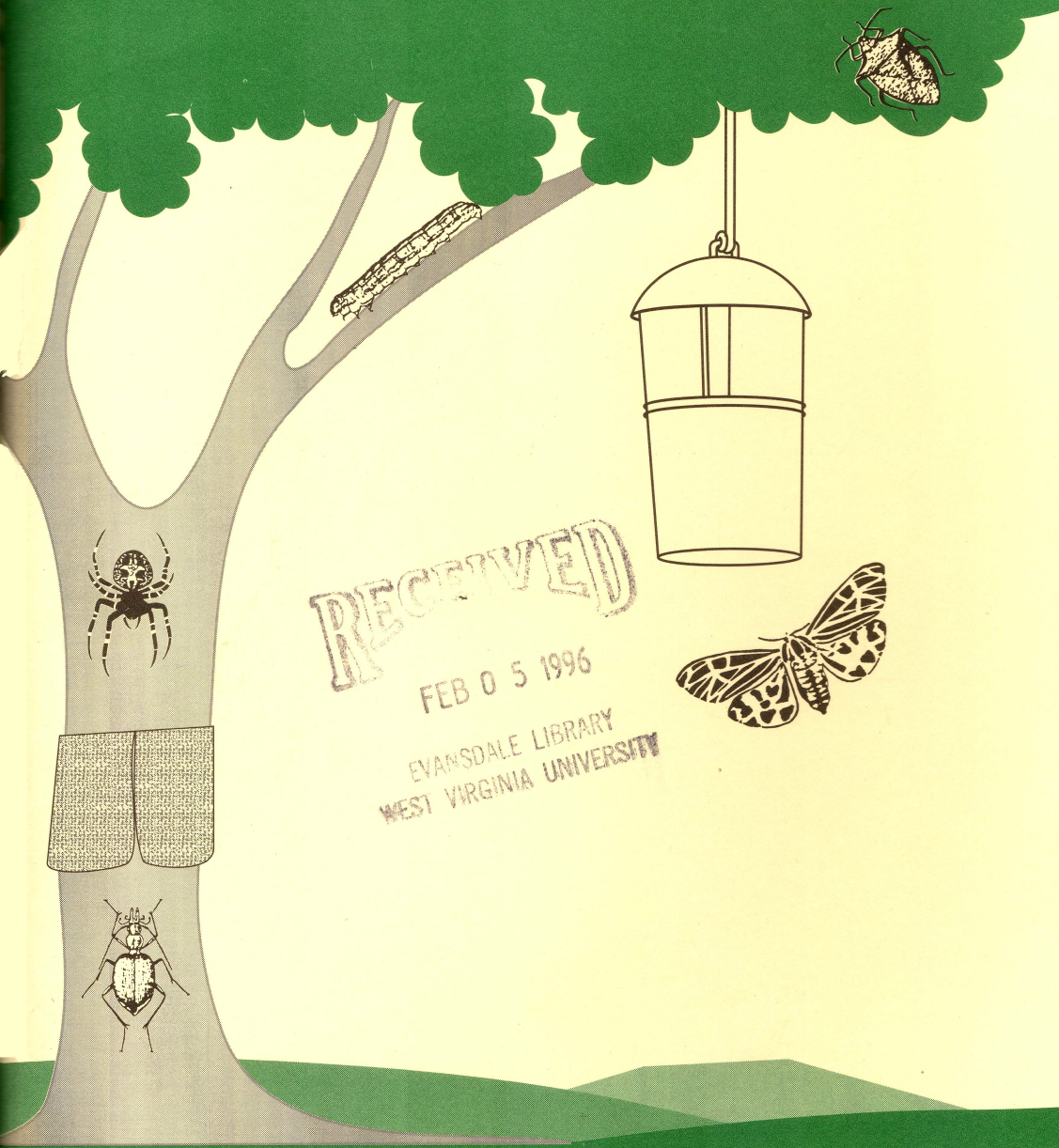
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Agricultural and Forestry Experiment Station
College of Agriculture and Forestry
Rosemary Haggett, Director
Morgantown, WV

Canopy Arthropods at Fernow Experimental Forest in West Virginia's Allegheny Mountain Section: III. Families of Arthropods on Foliage and Under Burlap Bands

Linda Butler, Gregory Chrislip and Vicki Kondo

INTRODUCTION

We began studying canopy arthropods in deciduous forests of West Virginia in 1984. Since that time our emphasis has been placed entirely or in large part on Macrolepidoptera in blacklight traps, on hardwood foliage, or under burlap/canvas bands (Butler 1992; Butler and Kondo 1991, 1993; Butler et al. 1995 a, b, c). The studies have been conducted for two purposes: (1) to collect baseline data prior to gypsy moth defoliation and subsequent application of insecticides, and (2) to evaluate the impact of gypsy moth suppression methods.

In 1989 we began a study to evaluate non-target impact of the insect growth regulator Dimilin (diflubenzuron) (1-4 chlorophenyl)-3-(2, 6-diflubenzoyl) urea) on canopy arthropods. Dimilin has been applied to hundreds of thousands of acres in the United States for suppression of gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae). From 1989 through 1994 we sampled arthropods in the forest canopy and under burlap bands in four closed watersheds on the Fernow Experimental Forest near Parsons in the Allegheny Mountain section of West Virginia. In 1992 Dimilin was applied to two of the watersheds. Elsewhere we present results of impact of the Dimilin on canopy arthropods, evaluation of macrolepidopterous moths sampled by blacklight trap, and richness and abundance of macrolepidopterous larvae on foliage and under bands. Here we present richness and abundance of arthropod families taken from foliage and collected during the six-year study period from burlap bands of mixed birch (*Betula* spp.), black cherry (*Prunus serotina* Ehrh.), mixed maples (*Acer* spp.) and mixed oaks (*Quercus* spp.). Used in this context, richness refers to number of families, abundance refers to total numbers of individuals.

MATERIALS AND METHODS

Study Sites

The Fernow Experimental Forest encompasses 1,902 ha and has been divided into a series of watersheds for research purposes. This study was conducted on watersheds 1, 4, 7, and 13. Prior to establishment of the Fernow Experimental Forest in 1934, the land was heavily cut between 1905 and 1910. Additional timbering occurred on several of the four watersheds from the early 1950s through the late 1970s. At the Fernow, common tree species on the better sites include yellow-poplar (*Liriodendron tulipifera* L.), sugar maple (*Acer saccharum* Marsh.), black cherry, white ash (*Fraxinus americana* L.), American basswood (*Tilia americana* L.) and red oak (*Quercus rubra* L.). Dominant tree species on the poorer sites include various species of oak (*Quercus* spp.), hickory (*Carya* spp.), sourwood (*Oxydendrum arboreum* (L.) DC) and sassafras (*Sassafras albidum* (Nutt.) Nees) (Adams et al. 1993).

Importance values (IV) for tree species on watersheds 1, 4, 7, and 13 were determined by Stephenson 1992 (unpublished) in which he evaluated species on five small plots (100 m²) within each watershed, well away from watershed boundaries. All plots with stems greater than 2.5 cm DBH (diameter breast height) were considered to be trees. Individual tree species were given an importance value by adding the relative basal area plus relative density and dividing by two. Stephenson's importance values are used to characterize vegetation on the four watersheds that comprised this study.

Watershed 1 is 30.11 ha with a NE aspect. It has not been timbered since 1958. Tree species with the highest importance values are sugar maple, American basswood, beech (*Fagus grandifolia* Ehrh.), black locust (*Robinia pseudoacacia* L.), cucumber magnolia (*Magnolia acuminata* L.) and red oak. Importance values for the four species groups sampled in this study were 29.2 for sugar maple, 2.6 and 1.5 for yellow birch (*Betula lutea* Michx. f.) and black birch (*Betula lenta* L.), respectively, and 3.7 for red oak. Red maple (*Acer rubrum* L.) and black cherry were sparse on watershed 1.

Watershed 4 is 38.73 ha with an ESE aspect. The most abundant tree species with respect to importance values are beech, sugar maple, striped maple (*Acer pensylvanicum* L.), yellow-poplar, American basswood and red oak. Importance values for trees sampled in this study were 16.6 and 2.4 for sugar maple and red maple, respectively, 1.0 for black birch and 7.4 for red oak. Black cherry was represented on watershed 4 by a few large trees and abundant young trees in the understory, but the young trees were too small to have been counted in Stephenson's importance values. Watershed 4 is a relatively mature forest, not having been timbered since 1910.

Watershed 7 is 24.23 ha with an E aspect. It is the youngest of the forest stands, having been last cut and treated with herbicides in 1969. The most abun-

dant species (IV) are black birch, sugar maple, red oak, and yellow-poplar. Importance values of trees sampled in this study were 15.4 for sugar maple, 9.2 for red oak, 33.3 for black birch and 8.4 for black cherry.

Watershed 13 is 14.23 ha with a NNE aspect. Light-selective timbering of this watershed occurred until 1960, but it is a relatively mature stand. Predominant species (IV) are sugar maple, red oak, yellow-poplar, black cherry and black birch. Importance values for species used in this study were 30.5 for sugar maple, 1.1 for red maple, 29.3 for red oak, 6.4 for black birch and 6.6 for black cherry.

Sampling Methods

We began sampling arthropods on all four watersheds in 1989 by means of burlap banding of trees and pole pruning of foliage.

Burlap bands 24 cm wide were stapled at breast height to trees. Ten trees each of black birch and black cherry were banded in late April 1989 on all four watersheds. Ten mixed maples were added on each watershed on 5 July 1989. Ten mixed oaks per watershed were added early May 1990 giving a total of 160 banded trees for the study. Each year bands were installed in late April and sampling was begun early to mid-May: 4 May 1989; 14 May 1990; 6 May 1991; 11 May 1992; 10 May 1993; and 9 May 1994. Bands were left in place until mid-August each year and then removed after the last sampling date: 15 August 1989; 13 August 1990; 12 August 1991; 10 August 1992; 9 August 1993; and 8 August 1994. Each week all bands were checked and all arthropods removed and returned to the laboratory for identification to family. Burlap bands mimic naturally occurring bark flaps serve as resting sites for arthropods that move up and down the trunks.

The first foliage samples were taken 17 May 1989 and consisted of two 25-branch tip samples of mixed birch (black and yellow) and two of black cherry on each of the four watersheds providing a total of 16 samples per sampling date. On 27 June 1989 a similar sampling procedure was added for mixed maple (sugar and red) for a total of 24 samples taken for the remainder of the season. Sampling of mixed oak (primarily red oak) was added at the beginning of the 1990 sampling season for a total of 32 samples of foliage on each sampling date.

Foliage sampling was begun soon after leaf expansion each spring: 17 May 1989; 15 May 1990; 7 May 1991; 12 May 1992; 11 May 1993; and 8 May 1994 and was continued until Mid-August each year. During the six years of the study, foliage samples were taken each week for a total of 15 sampling dates each season. Foliage was collected from low- to mid-canopy with pole pruners equipped with large plastic catch bags to collect the foliage that fell. The 32 foliage samples collected from mixed birch, black cherry, mixed maple and mixed oak were returned to the laboratory where all arthropods were removed and identified to family.

After arthropods were removed, all leaves from the twigs in each sample were placed in paper bags, oven dried, and weighed. The average dry weight of one foliage sample, regardless of foliage species, was about 50 grams. On 16 May 1992, Dimilin 4L was applied to watersheds 1 and 13 at a rate of 0.5 oz. AI/acre. Elsewhere we will discuss the impact of that treatment on canopy arthropods. Here we present overall richness and abundance of arthropods during the six-year study on the Fernow and present information on seasonal range and host associations. Voucher specimens from the study are deposited in the WVU Arthropod Collection.

RESULTS

From 1989 to 1994, arthropod family richness was 225 on foliage and 188 under bands of black birch, black cherry, mixed maples and mixed oaks (Table 1). Under bands, Phalangida was by far the most abundant taxon with more than 17,000 individuals being recorded (Table 2). Other taxa that were represented by more than 1,000 individuals during the study were Lymantriidae, Carabidae, Formicidae, Gryllacrididae, Agelenidae, Noctuidae, Diplopoda and Miridae. An additional 22 taxa were recorded in numbers exceeding 100, while for 74 taxa, numbers were five or less for the six-year study.

Taxa under burlap bands include those that typically move up from the forest-floor litter layer seeking shelter (Phalangida, Gryllacrididae, Diplopoda); those that move from the tree canopy downward seeking temporary shelter (Lymantriidae, Noctuidae), predators and omnivores that seek food on tree trunks (Carabidae, Formicidae, Agelenidae); and many "tourists" that were recorded in low numbers and opportunistically shelter under burlap.

Most taxa appear to show no affinity for bands on a particular tree species. Where notably greater numbers of individuals occur on a tree species, it is related to feeding preference of Lepidoptera: *Lymantria dispar*, Lymantriidae, preferring oak foliage; *Malacosoma americanum* (F.), Lasiocampidae, preferring black cherry. Some preference may also be shown for texture of tree bark.

Similar abundance of arthropods was noted for each of the four tree species groups. The mixed oaks had the highest abundance from burlap bands at 14,781 despite having not been sampled at all in 1989, the initial year of the study.

The most abundant foliage arthropods were the juice feeders Aphididae (with more than 27,000 individuals), Cicadellidae (with almost 11,000) and Miridae (with almost 10,000) (Table 3). Other families (or superfamilies) represented by more than 1,000 individuals include the thrips (Phlaeothripidae); the caterpillars of Geometridae, Noctuidae and Gelechiidae; the beetles (Curculionidae, Chrysomelidae, and Elateridae); the bark lice (Psocidae and Polypsocidae); the spiders (Theridiidae, Araneidae and Dictynidae); the plant-juice feeders (Membracidae, Eriosomatidae, Pentatomidae and Cercopidae); the flies (Sciaridae and Cecidomyiidae), and the Hymenoptera (Formicidae and Chalcidoidea).

An additional 51 taxa were represented by 100 or more individuals while 58 taxa were recorded as five or fewer individuals.

The mixed birch trees had the greatest abundance of arthropods at 51,771, followed by black cherry at 25,690, mixed maples at 22,420 and mixed oaks at 15,670. Particularly noteworthy was the abundance of Aphididae (19,951) and Cicadellidae (6,867) on birch, numbers that greatly exceeded any other taxon on any host tree species. Some other taxa with much higher numbers on one tree species group included Geometridae on black cherry, Membracidae on oak, Eriosomatidae on birch and Cercopidae on birch. Similar distribution of arthropod numbers among tree groups was seen for Phlaeothripidae, Theridiidae, Formicidae, Araneidae and Gelechiidae, among others. It must be noted again that sampling intensity was lower on oaks and maples than on birches and black cherry since a full sampling season with all four tree species groups was not begun until 1990.

Included on foliage in the forest canopy are the juice-feeding herbivores, chewing herbivores, predators, parasitoids, epiphytes (lichen and pollen feeders) and tourists, individuals that are "passing through."

DISCUSSION

The Fernow study has shown that the niches provided by trunks and canopies of hardwood trees are occupied by abundant and diverse arthropods. While high diversity is indicated by the 188 taxa under bands and 225 taxa on foliage, a much smaller number of taxa were relatively abundant in the two habitats.

Little difference was noted among tree species groups in richness and abundance of arthropods under bands. Since burlap bands mimic naturally occurring bark flaps, most of the arthropods occurring under burlap appear to be opportunistically seeking temporary shelter regardless of tree species.

Carabidae (ground beetles) is a large family of primarily predatory beetles that generally hide during the day under stones, logs, bark or debris and feed at night (Borror et al. 1989). These beetles were abundant under bands of all tree species groups.

The ants, Formicidae, are social insects that are found in great abundance in forests. Ants may nest in the soil, dead wood or living plant parts and may act as predators, scavengers or feed on seeds, sap, nectar or honeydew from juice-feeding insects (Borror et al. 1989). Ants use tree trunks as nesting sites and highways for food searching. It is interesting to note that more ants were taken from bands of oaks while more honeydew-producing sap-feeders on foliage were found on birch.

Gryllacrididae are cave and camel crickets that feed on decaying vegetation and fungi and are common in cracks and crevices, decaying logs and hollow trees (Blatchley 1920). Burlap bands apparently provide preferred sheltering sites for these arthropods.

Eighteen families of spiders were taken under bands. Spiders are predators of other arthropods and catch their prey by means of webs, foraging for and pouncing on prey or lying in wait for their prey (Borrer et al. 1989). The Agelenidae or funnel-web spiders were the most abundant spiders under bands and were frequently taken from small webs.

The second most abundant Lepidoptera larvae under bands were the Noctuidae, particularly the species *Polia latex* (Gn.), *Orthosia rubescens* (Wlk.), *Abagrotis alternata* (Grt.) and *Lithophane hemina* Grt. (Butler et al. 1995c). *Abagrotis alternata* moves from understory vegetation, particularly *Vaccinium* where it feeds, to shelter under bands. The other common noctuids use the foliage of the respective host trees under which bands they sheltered.

The millipedes (Diplopoda) are typically found in damp locations, under ground litter, in moss, soil or decayed wood (Borrer et al. 1989). They are commonly found in bark crevices on tree trunks and readily shelter under burlap bands.

Most mirid plant bugs are plant-juice feeders but some species are predators on other arthropods or are associated with fungi on tree trunks (Slater and Baranowski 1978). These are the mirid species most commonly taken under bands at Fernow.

Many of the less abundant arthropod taxa recorded in this study under burlap bands (Table 2) show life styles similar to those discussed: scavengers, predators or herbivores coming up from the litter layer; herbivores coming down from the canopy, or predators or lichen feeders foraging for food on tree trunks. Many of the taxa recorded under bands are likely to be opportunistically using bands for temporary shelter, including such beetles as Elateridae, Curculionidae, Cerambycidae and Scarabaeidae, flies such as Tipulidae, Anthomyiidae and Empididae, short-horned grasshoppers (Acrididae) and adult forms whose larvae are aquatic, such as nemourid and leuctrid stoneflies.

The most abundant family of foliage arthropods was Aphididae with 27,350 individuals over the six-year study. Seventy-three percent of the aphids were collected on birch. The Cicadellidae, the second most abundant family, were also most numerous on birch, representing 63 percent of the total leafhopper catches. Miridae, also a family of plant-juice feeders, was the third-ranked family on foliage and was recorded in greatest abundance on birch and maple. Thrips of the family Phlaeothripidae were the fourth most abundant. Members of this family are primarily predaceous on other arthropods (Borrer et al. 1989).

Chewing herbivores were well represented among the most abundant families on foliage. Geometrid larvae were in highest numbers, with 5,688 being recorded during the study. Fifty-seven percent of these were taken from black cherry and were primarily *Lomographa* spp. (Butler et al. 1995c). Other abundant mandibulate herbivores included the weevils (Curculionidae), leaf beetles (Chrysomelidae) and caterpillars of the families Noctuidae and Gelechiidae. Two

families of Psocoptera (Psocidae and Polypsocidae) were abundant on the foliage; these insects feed primarily on lichens, pollen and algae (Borror et al. 1989).

The spiders of the families Theridiidae, Araneidae and Dictynidae were relatively abundant on foliage. Members of all three of these families construct webs with which they capture prey (Borror et al. 1989).

Additional juice-feeding insects that were recorded at 1,000 or above include the Membracidae (treehoppers), Eriosomatidae (woolly and gall aphids), Pentatomidae (stink bugs) and Cercopidae (spittlebugs). Some pentatomids on foliage are predaceous, not herbivorous.

Among the Diptera, the most abundant were the Sciaridae (fungus gnats) whose adults rest in the canopy but whose larvae live primarily in fungi. The Cecidomyiidae (Diptera) gall midges were also relatively abundant as were the Chalcidoidea (Hymenoptera), whose members are primarily parasitic on other insects. Lastly, among the taxa recorded in numbers greater than 1,000 were the Elateridae, whose larvae feed on plant roots or in decayed wood while adults are herbivores.

From 1990 to 1992, Butler et al. (1995a) evaluated arthropod richness and abundance in canopies of mixed oaks in West Virginia's Eastern Ridge and Valley section. Methods similar to those in the current study were used. On oak, during the three-year period, we recorded 200 taxa of arthropods. The most abundant taxa were Aphididae, Lymantriidae, Curculionidae, Tenthredinidae, Pergidae, Coccidae, Cicadellidae, Noctuidae, Reduviidae and Miridae. The study sites were predominantly oak, while the Fernow watersheds were much more diverse in tree composition. This may account for the overall high arthropod diversity in the Fernow trees during the current study. We note however, that diversity in oak canopies was higher in the Butler et al. (1995a) study than in the Fernow study. Gypsy moth populations were increasing in the Eastern Ridge and Valley section during the earlier study, accounting for the high abundance in the Lymantriidae. The sawflies (Tenthredinidae and Pergidae) were particularly abundant on oaks in the earlier study but in moderate to low numbers at Fernow. Otherwise, many similarities exist between the two studies in overall composition of arthropods.

Pachamuthu and Butler (submitted manuscript) evaluated richness and abundance in canopies of chestnut oak at Coopers Rock State Forest in 1992 and 1993 and found Membracidae, Aphididae, Lymantriidae, Miridae, Gryllidae, Geometridae, and Gelechiidae to be most abundant.

Canopy arthropods constitute one of the richest and least studied faunas on earth (Blanton 1990). Numerous researchers have recommended the need for more information on composition, trophic structures and species diversity of canopy arthropods (Hijii 1983; Schowalter and Crossley 1983).

SUMMARY

Arthropods were collected weekly from burlap bands and foliage of birch, black cherry, maple and oak May–August 1989–1994. Taxon (primarily family) richness was 188 for bands and 225 for foliage. Total arthropod abundance was 115,551 on foliage and 47,788 under bands. The most abundant arthropods under bands were Phalangida > Lymantriidae > Carabidae > Formicidae > Gryllacrididae. Arthropods most abundant on foliage were Aphididae > Cicadellidae > Miridae > Phlaeothripidae > Geometridae. Canopy and tree trunk arthropods are diverse and numerous on the Fernow Experimental Forest.

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TABLE 1.
Richness¹ and abundance of arthropods on foliage and under bands
of mixed birch, black cherry, mixed maples and mixed oaks
at Fernow Experimental Forest, West Virginia, 1989–1994².

	Tree Species				Total
	Mixed Birch	Black Cherry	Mixed Maple	Mixed Oak	
Foliage Richness	163	170	160	171	225
Foliage Abundance	51,771	25,690	22,420	15,670	115,551
Band Richness	136	136	133	129	188
Band Abundance	10,435	10,864	11,708	14,781	47,788

¹Richness refers to number of taxa collected during the study; the taxon categories expressed in this paper are primarily arthropod families.

²Mixed oaks were not sampled in 1989.

TABLE 2.
Abundance of arthropods listed by taxa (primarily families) collected
from burlap bands of black birch, black cherry, mixed maple and mixed oak
at Fernow Experimental Forest, 1989–1994. Taxa are arranged
from most to least abundant.

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Phalangida	3450	4289	4334	5134	17002
Lymantriidae	788	583	891	2308	4570
Carabidae	1195	749	1024	962	3930
Formicidae	827	464	866	1209	3366
Gryllacrididae	708	770	788	1036	3302
Agelenidae	574	790	859	867	3090
Noctuidae	470	973	425	497	2365
Diplopoda	186	262	332	395	1175
Miridae	224	180	361	369	1134
Entomobryidae	423	137	182	168	910
Theridiidae	162	168	196	131	657
Geometridae	63	91	78	129	361
Chilopoda	113	48	102	85	348
Clubionidae	62	58	84	106	310
Elateridae	71	41	72	87	271
Tenebrionidae	30	59	64	108	261
Pentatomidae	39	96	67	57	259
Salticidae	65	50	63	75	253
Lasiocampidae	34	120	46	52	252
Tortricidae	57	53	57	51	218
Tipulidae	52	54	48	55	209
Tenthredinidae	31	31	31	86	179
Reduviidae	20	56	48	43	167
Gryllidae	25	41	45	52	163
Membracidae	38	15	39	70	162
Coccinellidae	65	28	19	45	157
Chrysomelidae	36	59	33	23	151
Psocidae	82	8	40	5	135
Curculionidae	30	18	26	58	132
Cerambycidae	24	27	27	24	102
Arctiidae	17	37	19	28	101
Araneidae	27	23	32	7	89
Gelechiidae	14	25	14	33	86
Machilidae	20	16	18	23	77
Acrididae	17	25	21	13	76
Cantharidae	15	15	12	15	57
Anthomyiidae	18	7	9	22	56
Philodromidae	11	11	14	13	49
Chalcidoidea	3	41	1	3	48

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Ichneumonidae	11	13	13	10	47
Coreidae	8	25	7	7	47
Thomisidae	9	13	9	13	44
Lampyridae	11	13	12	7	43
Nitidulidae	0	6	2	27	35
Empididae	7	12	9	7	35
Lygaeidae	8	13	9	5	35
Anyphaenidae	11	8	7	7	33
Scarabaeidae	5	6	10	11	32
Rhagionidae	4	4	20	4	32
Nemouridae	14	14	4	0	32
Lagriidae	3	5	10	12	30
Bibionidae	7	2	6	14	29
Cicadellidae	9	10	6	1	26
Leuctridae	9	11	2	3	25
Melandryidae	11	4	3	5	23
Sminthuridae	2	12	0	9	23
Pyralidae	7	4	6	4	21
Staphylinidae	9	2	6	3	20
Mycetophilidae	7	6	4	3	20
Aphididae	10	4	4	2	20
Tachinidae	1	4	5	9	19
Perlidae	5	10	3	1	19
Halictidae	3	5	7	3	18
Sciaridae	4	5	4	4	17
Oedemeridae	5	1	5	5	16
Pisauridae	2	3	5	6	16
Trombidia	7	2	3	4	16
Chloroperlidae	4	8	4	0	16
Panorpidae	3	5	6	2	16
Buprestidae	0	7	4	4	15
Ostomatidae	13	0	0	1	14
Pedilidae	8	2	3	1	14
Cecidomyiidae	0	0	2	12	14
Braconidae	0	2	1	11	14
Vespidae	2	2	6	4	14
Delphacidae	5	3	3	3	14
Pyrochroidae	0	3	8	2	13
Polypsocidae	0	0	13	0	13
Mordellidae	4	2	4	2	12
Andrenidae	3	1	1	7	12
Linyphiidae	5	1	2	4	12
Erotylidae	6	3	1	1	11
Syrphidae	3	2	4	2	11
Cercopidae	4	3	2	2	11

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Nabidae	1	3	3	4	11
Coccidae	10	0	0	0	10
Notodontidae	0	3	2	5	10
Silphidae	1	0	1	7	9
Cleridae	0	4	3	2	9
Argidae	2	5	1	1	9
Micryphantidae	3	2	2	2	9
Phoridae	2	2	0	4	8
Apidae	3	3	1	1	8
Cimbicidae	4	4	0	0	8
Diprionidae	4	4	0	0	8
Lycosidae	1	1	5	1	8
Oecophoridae	2	2	2	2	8
Lycaenidae	0	1	3	4	8
Plecoptera	1	6	0	1	8
Anobiidae	2	2	1	2	7
Lucanidae	0	1	0	6	7
Chironomidae	5	1	0	1	7
Tettigoniidae	1	2	1	3	7
Athericidae	0	2	3	1	6
Sphecidae	2	3	1	0	6
Dictyopharidae	1	2	3	0	6
Perlodidae	2	4	0	0	6
Mycetophagidae	2	1	2	0	5
Endomychidae	1	2	1	1	5
Dolichopodidae	1	1	2	1	5
Anthophoridae	1	0	0	4	5
Anthocoridae	1	0	1	3	5
Dictynidae	1	1	1	2	5
Sphingidae	2	2	0	1	5
Papilionidae	1	1	1	2	5
Anthicidae	1	1	1	1	4
Muscidae	1	1	0	2	4
Alydidae	1	0	2	1	4
Chrysopidae	0	0	3	1	4
Gnaphosidae	1	0	0	3	4
Lycidae	1	0	2	0	3
Cucujidae	1	0	0	2	3
Psychodidae	1	0	2	0	3
Pompilidae	0	1	1	1	3
Psyllidae	1	1	0	1	3
Gracillariidae	0	0	0	3	3
Heptageniidae	2	1	0	0	3
Alleculidae	0	0	1	1	2
Bostrichidae	1	1	0	0	2

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Phalacridae	2	0	0	0	2
Brentidae	1	0	1	0	2
Ptilodactylidae	1	0	1	0	2
Lathridiidae	0	1	1	0	2
Lauxaniidae	1	1	0	0	2
Calliphoridae	0	1	1	0	2
Tabanidae	0	0	1	1	2
Lonchopteridae	0	0	2	0	2
Heleomyzidae	0	1	0	1	2
Cynipidae	0	0	1	1	2
Xyelidae	0	2	0	0	2
Xiphydriidae	1	0	1	0	2
Achilidae	1	1	0	0	2
Aradidae	2	0	0	0	2
Hemerobiidae	1	1	0	0	2
Limnephilidae	1	0	1	0	2
Amaurobiidae	1	0	1	0	2
Segestriidae	1	0	0	1	2
Anystidae	1	0	0	1	2
Coleophoridae	0	1	0	1	2
Blattellidae	0	0	0	2	2
Phasmatidae	0	0	0	2	2
Mantidae	1	1	0	0	2
Microcoryphia	1	0	0	1	2
Aeshnidae	0	1	1	0	2
Scolytidae	0	0	1	0	1
Dermestidae	0	1	0	0	1
Anthribidae	0	0	1	0	1
Meloidae	0	1	0	0	1
Bruchidae	0	0	0	1	1
Melyridae	0	0	1	0	1
Cryptophagidae	0	1	0	0	1
Stratiomyidae	1	0	0	0	1
Sarcophagidae	0	0	0	1	1
Chloropidae	0	0	1	0	1
Anthomyzidae	0	0	1	0	1
Proctotrupoidae	0	1	0	0	1
Pamphiliidae	0	1	0	0	1
Siricidae	0	0	1	0	1
Cephidae	1	0	0	0	1
Homoptera	1	0	0	0	1
Cixiidae	0	0	1	0	1
Eriosomatidae	1	0	0	0	1
Rhopalidae	0	0	0	1	1
Tingidae	0	0	1	0	1

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Cydnidae	1	0	0	0	1
Sialidae	1	0	0	0	1
Phryganeidae	0	1	0	0	1
Hydroptilidae	0	1	0	0	1
Tetragnathidae	0	0	1	0	1
Theridiosomatidae	0	1	0	0	1
Nymphalidae	0	0	0	1	1
Lyonetiidae	0	0	1	0	1
Glyphipterigidae	1	0	0	0	1
Thyatiridae	1	0	0	0	1
Siphonuridae	0	1	0	0	1
Peltoperlidae	0	0	1	0	1
Libellulidae	0	0	1	0	1
Diplura	0	1	0	0	1
Drepanidae	0	1	0	0	1
TOTALS	10435	10864	11708	14781	47788

TABLE 3.

Abundance of arthropods listed by taxa (primarily families) collected from foliage of mixed birch, black cherry, mixed maple and mixed oak at Fernow Experimental Forest, 1989–1994. Taxa are arranged from most to least abundant.

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Aphididae	19951	632	3995	2772	27350
Cicadellidae	6867	1810	1534	620	10830
Miridae	3304	1495	3668	1196	9664
Phlaeothripidae	1874	2420	1347	683	6324
Geometridae	719	3217	992	760	5688
Curculionidae	1554	1371	526	472	3923
Psocidae	615	1297	683	578	3173
Polypsocidae	770	1458	651	288	3167
Theridiidae	653	974	893	423	2943
Membracidae	189	57	42	2035	2323
Eriosomatidae	1996	5	14	73	2087
Sciaridae	795	709	454	26	1984
Formicidae	738	403	467	365	1972
Araneidae	485	478	553	264	1781

continued

Family	Tree Species Groups				
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	Total
Noctuidae	655	428	262	314	1659
Gelechiidae	343	497	325	489	1654
Chrysomelidae	705	421	138	262	1526
Dictynidae	295	521	558	131	1505
Pentatomidae	570	385	166	130	1251
Cercopidae	814	89	163	52	1118
Cecidomyiidae	549	344	136	62	1091
Chalcidoidea	381	265	189	171	1006
Elateridae	312	309	258	124	1003
Philodromidae	239	239	290	194	962
Proctotrupoidea	422	303	123	53	901
Tenthredinidae	181	333	19	321	853
Reduviidae	376	199	173	98	846
Phalangida	270	211	206	102	789
Linyphiidae	137	258	213	112	719
Lyoniidae	161	267	173	102	704
Tortricidae	144	242	112	154	651
Coccidae	301	165	48	83	597
Cantharidae	252	128	117	84	581
Chironomidae	251	113	115	55	533
Entomobryidae	181	148	105	59	493
Psyllidae	181	54	185	67	487
Lygaeidae	253	151	54	6	464
Salticidae	142	118	92	95	448
Tipulidae	112	156	122	48	439
Coccinellidae	138	118	62	109	427
Braconidae	110	158	107	51	426
Mycetophilidae	133	132	111	36	412
Hemerobiidae	132	100	80	84	396
Gracillariidae	116	182	68	27	393
Thomisidae	138	113	93	46	390
Ichneumonidae	106	90	76	51	323
Syrphidae	166	59	46	44	316
Lymantriidae	30	26	57	197	310
Tingidae	36	188	32	10	266
Empididae	146	45	38	32	262
Anyphaenidae	72	64	72	45	254
Thripidae	50	26	132	27	234
Lasiocampidae	0	169	3	53	225
Coniopterygidae	24	32	121	44	221
Pyrilidae	46	56	71	43	216
Notodontidae	23	8	88	70	189
Anystidae	65	59	25	39	187
Staphylinidae	63	57	24	37	180
Phylloxeridae	12	8	78	74	172

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Lauxaniidae	61	65	30	10	165
Lathridiidae	42	60	31	29	162
Trombidia	71	41	31	15	157
Clubionidae	34	42	59	16	151
Nemouridae	58	25	34	12	128
Arctiidae	31	18	16	59	124
Cynipidae	45	27	16	31	118
Dictyopharidae	49	52	12	1	114
Scarabaeidae	35	5	25	48	113
Chrysopidae	41	42	14	10	107
Micryphantidae	17	44	35	11	107
Sminthuridae	73	12	5	15	105
Tetragnathidae	45	36	13	11	105
Acarina	75	17	8	2	102
Leuctridae	44	17	31	8	100
Gryllidae	36	18	16	8	78
Pselaphidae	17	23	11	27	77
Anthomyiidae	23	37	3	14	76
Bibionidae	19	32	17	7	76
Mordellidae	17	25	19	10	71
Agelenidae	24	12	26	9	70
Cerambycidae	20	27	15	7	68
Drosophilidae	29	13	15	11	68
Simuliidae	4	28	22	5	59
Phalacridae	15	18	12	12	57
Nitidulidae	12	40	1	2	56
Leiodidae	21	23	3	9	56
Ceratopogonidae	20	19	14	2	55
Argidae	11	38	0	6	55
Carabidae	29	11	6	6	51
Nabidae	15	20	6	9	50
Thysanoptera	0	46	2	0	48
Panorpidae	13	8	13	13	47
Rhagionidae	18	5	14	5	42
Limacodidae	11	8	8	15	42
Saturniidae	0	0	31	10	41
Muscidae	18	12	7	1	38
Anobiidae	5	10	19	2	36
Phoridae	5	13	15	1	34
Pamphiliidae	20	14	0	0	34
Pergidae	8	15	0	10	32
Psychodidae	12	7	5	8	31
Dolichopodidae	5	13	9	0	27
Mycetophagidae	0	8	11	5	25
Lycaenidae	0	1	0	24	25

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Oedemeridae	10	9	2	3	24
Chloroperlidae	3	0	16	6	24
Cimbicidae	5	15	1	1	23
Diprionidae	5	15	1	1	23
Thyatiridae	2	0	20	1	23
Cryptophagidae	0	10	9	2	20
Scatopsidae	13	3	0	4	20
Peltoperlidae	5	8	6	1	20
Drepanidae	19	0	1	0	20
Stratiomyidae	2	5	7	4	19
Tettigoniidae	8	8	1	2	19
Halictidae	6	9	3	0	18
Melandryidae	8	6	1	2	17
Corylophidae	0	17	0	0	17
Anthocoridae	5	0	10	2	16
Gryllacrididae	11	2	3	1	16
Lampyridae	7	2	5	1	15
Chloropidae	2	11	0	2	15
Acridae	6	1	0	8	15
Sciomyzidae	5	2	7	0	14
Cixiidae	1	3	4	5	14
Coreidae	3	8	0	3	14
Perlodidae	6	0	6	1	14
Otitidae	4	3	4	2	13
Pisauridae	7	2	3	1	13
Sphingidae	2	7	0	4	13
Melyridae	3	7	2	0	12
Piophilidae	5	6	0	1	12
Tineidae	2	1	5	3	12
Baetidae	4	4	3	1	12
Bittacidae	3	5	2	2	12
Alleculidae	6	2	2	1	11
Lycidae	5	3	2	1	11
Pedilidae	6	2	2	1	11
Oribatidae	0	6	5	0	11
Pyrochroidae	3	4	2	2	10
Pipunculidae	2	3	0	4	10
Agromyzidae	10	0	0	0	10
Coleophoridae	0	10	0	1	10
Scolytidae	8	0	1	0	9
Sphecidae	5	3	0	2	9
Gasteruptionidae	4	0	0	5	9
Derbidae	5	2	1	1	9
Anthicidae	3	0	3	2	8
Achilidae	0	0	8	0	8

continued

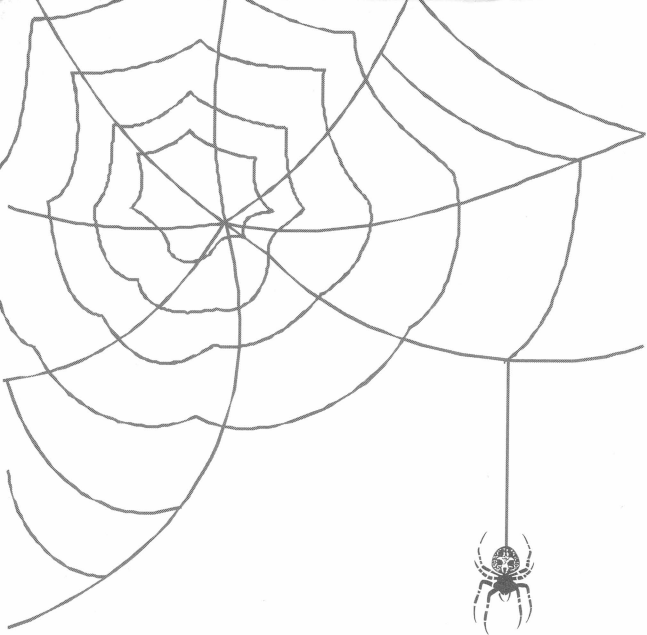
Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Alydidae	2	2	2	1	8
Heptageniidae	1	6	0	0	8
Cleridae	2	2	1	1	7
Tephritidae	1	2	3	1	7
Xylophagidae	7	0	0	0	7
Buprestidae	1	0	3	2	6
Helodidae	0	2	4	0	6
Histeridae	6	0	0	0	6
Lagriidae	3	1	0	2	6
Ptilodactylidae	2	2	0	1	6
Tachinidae	3	0	0	3	6
Lonchaeidae	0	6	0	0	6
Culicidae	4	2	0	0	6
Xylomyidae	4	0	0	2	6
Anthophoridae	0	0	0	6	6
Berytidae	4	2	0	0	6
Uloboridae	0	6	0	0	6
Papilionidae	0	6	0	0	6
Cucujidae	2	3	0	0	5
Byrrhidae	0	2	0	3	5
Sphaeroceridae	5	0	0	0	5
Acroceridae	1	3	0	1	5
Hydropsychidae	2	0	2	1	5
Oecophoridae	0	2	2	1	5
Dascillidae	0	2	2	0	4
Cephaloidae	2	1	0	0	4
Lonchopteridae	0	0	3	1	4
Phymatidae	0	2	3	0	4
Philopotamidae	0	2	0	2	4
Eriocraniidae	0	4	0	0	4
Bostrichidae	0	2	1	1	3
Bombyliidae	0	0	1	2	3
Cephidae	0	0	0	3	3
Delphacidae	0	1	2	0	3
Flatidae	0	2	0	1	3
Brachycentridae	0	3	0	0	3
Isotomidae	0	3	0	0	3
Lycosidae	0	0	3	0	3
Silphidae	2	0	0	0	2
Artematopidae	0	2	0	0	2
Ephydridae	0	2	0	0	2
Chrysididae	2	0	0	0	2
Limnephilidae	0	0	2	0	2
Rhyacophilidae	0	0	0	2	2
Siphonuridae	2	0	0	0	2

continued

Family	Tree Species Groups				Total
	Black Birch	Black Cherry	Mixed Maple	Mixed Oak	
Baetiscidae	0	0	2	0	2
Diplopoda	0	0	1	1	2
Nymphalidae	0	1	0	1	2
Coleoptera	0	0	0	1	1
Erotylidae	0	0	0	1	1
Lucanidae	0	0	0	1	1
Rhipiceridae	0	0	0	1	1
Endomychidae	0	0	1	0	1
Salpingidae	0	0	0	1	1
Calliphoridae	0	0	0	1	1
Anisopodidae	1	0	0	0	1
Anthomyzidae	0	0	1	0	1
Camillidae	1	0	0	0	1
Curtonotidae	0	0	0	1	1
Athericidae	0	0	1	0	1
Hymenoptera	0	0	0	1	1
Colletidae	0	1	0	0	1
Xyelidae	0	1	0	0	1
Pelecinidae	0	0	0	1	1
Andrenidae	0	0	1	0	1
Homoptera	1	0	0	0	1
Acanaloniidae	0	0	1	0	1
Phryganeidae	0	0	1	0	1
Hydroptilidae	0	0	1	0	1
Amaurobiidae	0	0	1	0	1
Oxyopidae	0	0	1	0	1
Plutellidae	0	0	1	0	1
Tischeriidae	0	0	0	1	1
Ephemerellidae	0	0	0	1	1
Perlidae	0	0	0	1	1
Chilopoda	0	1	0	0	1
TOTALS	51771	25690	22420	15670	115551

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